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(58) Field of Search

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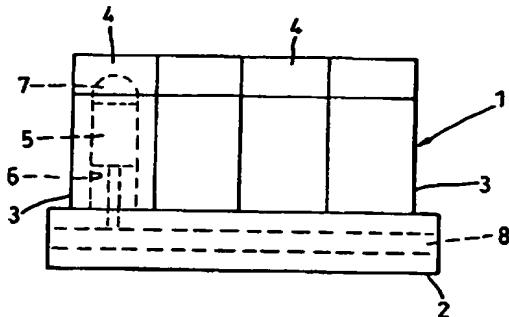
INT CL<sup>8</sup> F01B 1/12, F02B 73/00, F02F 7/00

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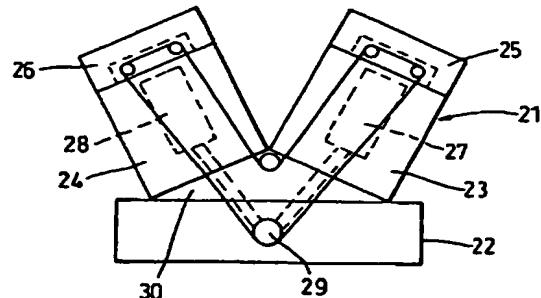
(54) Abstract Title

Modular I.c. engine

(57) An engine (1; 21) is of a modular construction, the modules comprising cylinder blocks (3; 23, 24) secured through appropriate couplings to a crankcase (2; 22) and respective cylinder heads (4; 25, 26). The couplings between the crankcase (2; 22) and the cylinder blocks (3; 23, 24) are such that the engine (1; 21) can have a variable construction in terms of the number of cylinders included along with the relative orientation of respective inlet and outlet means for fuel and exhaust gas to the engine. In such circumstances, empirical trials of the engine (1; 21) can be conducted by varying individual modular components, e.g. cylinder block (3; 23; 24), along with operation of control mechanisms and the cylinder head (4; 25, 26).



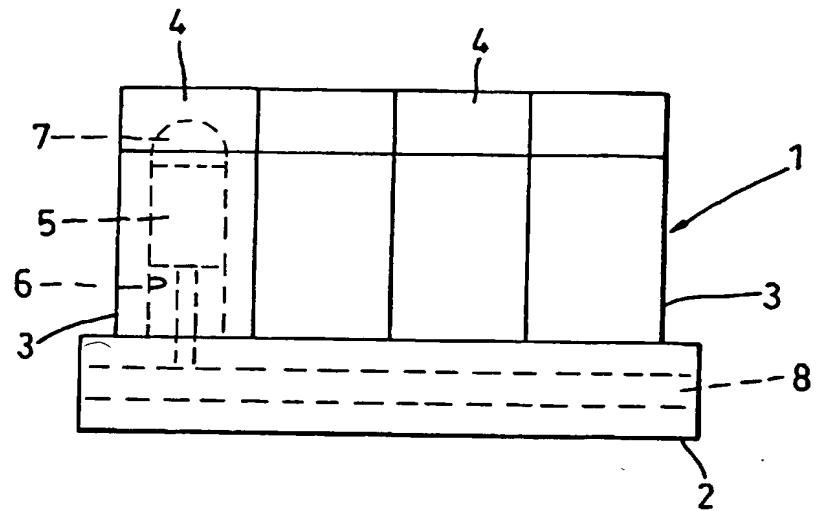
**Fig. 1**



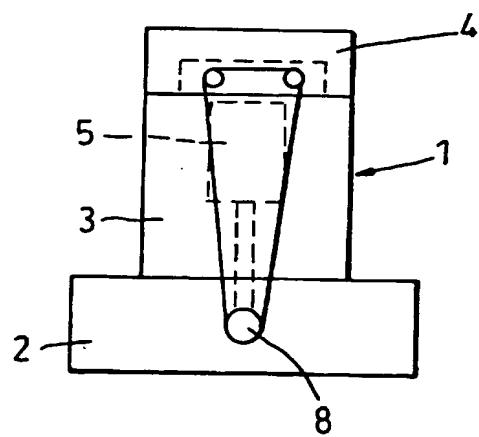
**Fig. 4**

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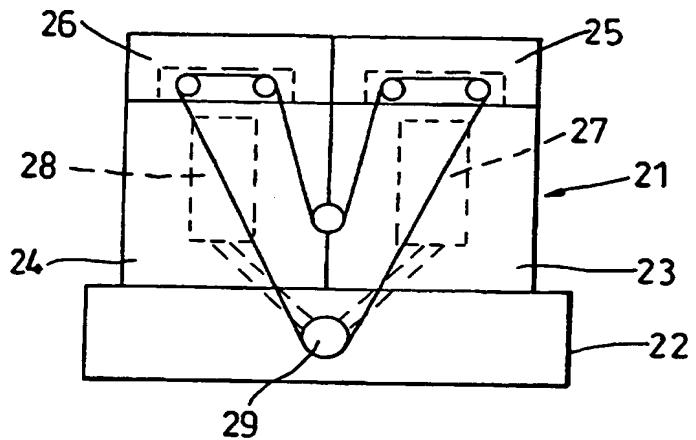


***Fig. 1***

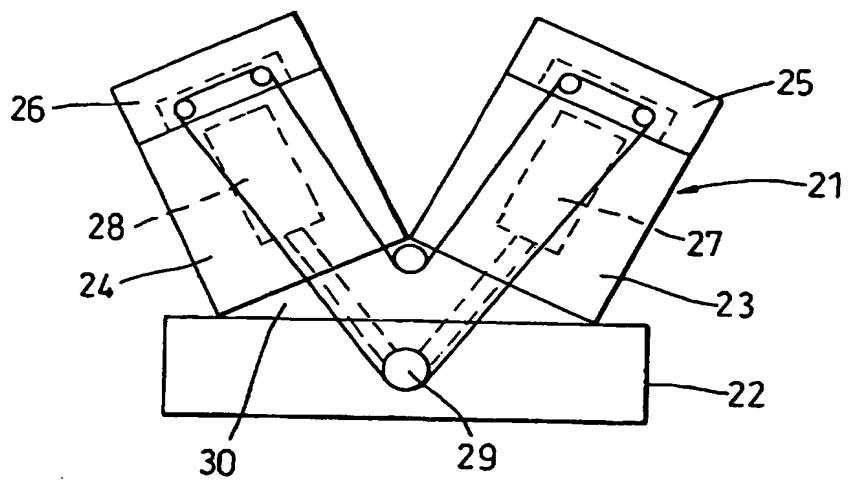


***Fig. 2***

**2/2**



***Fig. 3***



***Fig. 4***

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AN ENGINE

The present invention relates to an engine and more particularly to an engine of variable construction to allow performance determinations in various configurations of that engine.

Clearly, there is an on-going requirement and desire to improve both engine  
5 performance, economy and emissions in order to meet strict environmental regulations and customer desire. Unfortunately, despite improved computer modelling and simulation, it is not possible to accurately predict engine behaviour in terms of performance, emissions and economy by extrapolation from computer designed engines. Engine performance, emissions and economy are governed by  
10 the number and type of combustion/inlet/exhaust system used within the engine. These factors are closely inter-related and have a significant one upon the other, but currently it is not possible to combine the effects of these factors without actually forming a prototype engine for test.

The costs of creating a bespoke prototype engine in order to determine the  
15 combined effects of combustion systems with inlet/exhaust systems is expensive. Thus, there is a degree of extrapolation and refining of existing systems rather than an opportunity to perform a fundamental review and radical alteration in engine construction to achieve best performance, emission and economy for an engine over a particular expected power range.

20 It is an object of the present invention to provide an engine which allows greater variation in construction in order to determine the effects of the number and type of combustion system along with inlets/exhaust system upon engine performance, emissions and economy.

In accordance with the present invention there is provided an engine comprising a crank case to accommodate a crank shaft therethrough, at least one piston block secured to the crank case and with a piston therein coupled to the crankshaft and each piston block being secured to a head member in order to

5 define a combustion chamber therebetween the piston and the head member in which fuel combustion presents workload through displacement of the piston to the crankshaft in order to rotate that crankshaft and rotation of that crankshaft through a reciprocal timing coupling to combustion control means in each head member coordinates combustion within each piston block and therefore piston

10 displacement for cooperative rotation therebetween of the crankshaft, the engine characterised in that the number of and/or relative angle of presentation between each piston block and the crank case is variable through alteration of configuration means located between each piston block and the crank case whilst maintaining respective piston displacement for cooperative rotation therebetween of the

15 crankshaft.

The configuration means may include engine and/or slide mechanisms between each piston block and the crankcase.

Incorporated with the crankshaft is typically a flywheel and this flywheel may be of variable weight and configuration.

20 The engine may include blanking plates secured to the crank case at locations adapted to accommodate a piston block such that the engine is still operational without such a piston block being in place.

Typically, such a crank case will be segmented or comprise compartments for each respective piston block. These compartments may be divided by bearing plate  
25 also adapted to support the crankshaft.

Normally, each discrete portion of the engine will be substantially independently lubricated. Thus, each piston block, the crank case and the respective head members will each retain their own lubrication. However, lubrication piping may be provided between said piston blocks, crank case and  
5 head members if required.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1 is a pictorial side elevation of an engine;

Figure 2 is a pictorial front elevation of the engine depicted in Figure 1;

10 Figure 3 is a pictorial front elevation of an alternative engine in a first configuration or construction; and

Figure 4 is a pictorial front elevation of the engine depicted in Figure 3 in a second engine configuration or construction.

Clearly, an internal combustion engine typically comprises a cylinder or  
15 piston block associated with a head member in order to define a combustion chamber therebetween. In a conventional engine, in order to reduce costs, a number of cylinders are located within one engine block and similarly the head member mechanism also extends over several cylinders in order to reduce costs both in terms of materials and machining. Unfortunately, as indicated above, such  
20 a configuration does not allow variation in construction in order to improve engine performance, emissions and economy by trying different combustion chamber configurations along with inlet/exhaust manifold arrangements.

In accordance with the present invention an engine 1 is formed from modular components. Thus, a crank case 2 is associated with piston blocks 3 which in turn are coupled to head members 4 to provide the broad engine configuration. With such a modular construction, it will be appreciated that different geometries can  
5 be provided for the engine 1 within the general context of an operational arrangement.

The engine 1 is generally in accordance with known internal combustion engine operational regimes. Thus, a piston 5 is located within a cylinder 6 such that a combustion chamber 7 can, in accordance with a timed regime, receive fuel  
10 which is then ignited by an appropriate mechanism in the head member 4 in order to displace the piston 5 and so perform work to turn a crank shaft 8. Clearly, the head member 4 includes appropriate means for injecting combustible fuel and releasing exhaust gases. The engine 1 can operate in accordance with known four stroke (Otto) cycle requirements or alternatively a two stroke cycle. The  
15 crankshaft 8 will normally be coupled to a flywheel in order to smooth power fluctuations presented to that shaft 8 through displacement of piston 5 and any other pistons in any other piston blocks 3 by conservation of inertia. Clearly, in accordance with known principles, the crankshaft 8 will be coupled in reciprocal time coordination with appropriate control mechanisms within the head members  
20 4 in order to open and close respectively fuel inlet and exhaust gas outlet valves. This reciprocal timing will normally be through timing chains or timing belts and appropriate pulleys between the crankshaft 8 and the control mechanisms in the head members 4. The above mechanism is substantially conventional for an internal combustion engine.

25 In accordance with the present invention, as indicated above, the engine 1 is modularised. Thus, when it is desired to alter the engine construction only one modular component of the engine 1 needs to be replaced in order to provide that

construction variation whilst the remainder of the engine 1 is retained and the whole is still operational. It will be appreciated, that the engine 1 could comprise a single piston block 5 and head member 4 with other portions of the engine 1 blanked off with appropriate blank plates where piston blocks could be secured to

5 the crank case in order to maintain a fully operational engine 1. Thus, the effects of that single piston block 3 and head member 4 can be accurately analysed alone or in conjunction with other piston blocks within the engine 1. This flexibility allows a far greater evaluation of engine 1 performance and clearly renders easier determine of adaptation of the engine 1 to maximise performance along with

10 adjustment of fuel economy and emissions.

It is easier to replace a single module within the engine 1 rather than provide a whole prototype engine block, etc, in accordance with previous practice. Thus, variations in engine 1 construction can be tried in order to note the alterations in performance, economy and emissions. The principle engine 1 construction

15 variation will clearly be with regard to shaping of the combustion chamber 7 and inlet/outlet valving within the head member 4. In such circumstances, as depicted in the Figures, normally the crank case 2 will be a single element incorporating appropriate bearings at each end to support the crankshaft 8. Within the crank case 2 partitioned compartments or segments will be defined upon which a

20 respective piston block 3 may be located and possibly including bearing panels to support the crankshaft 8. Those compartments or segments which are not in use at any one time may be blanked off as indicated previously with blanking plates. In such circumstances, each crank case 2, piston block 3 and head member 4 will constitute a discrete work engine providing rotation to the crank shaft 8 as a

25 result of combustion within the combustion chamber 7. For convenience, typically each modular component of the engine 1 will be independently lubricated in that a respective lubricating oil or otherwise will be allocated to that modular component

in order to ensure that adequate lubrication is provided. In order to achieve this independent lubrication for each modular component of the engine 1 an appropriate filler aperture and where necessary drainage plug will be provided for each modular component. It will also be understood that these respective modular components could be coupled together through lubrication piping, ie. secured at each filling or drain aperture in order to achieve oil distribution through the engine 1 if required.

Figures 1 and 2 illustrate an embodiment of the present invention in which the cylinder blocks 3 and therefore the engine 1 are in a so-called in-line configuration, one behind the other. Clearly, alternative engine configurations can be used including staggered and V. Thus, an alternative engine 21 is depicted in Figures 3 and 4. In this alternative engine 21, a crank case 22 is associated with respective piston blocks 23, 24 which in turn are coupled to head members 25, 26. The assembly of crank case 22 with piston blocks 23, 24 and head members 25, 26 operate in accordance with similar principles to those described with regard to the in-line engine 1 described with regard to Figures 1 and 2. Thus, a respective piston 27, 28 within each piston block 23, 24 is displaced by combustion in order to rotate a crankshaft 29. Reciprocal timing between the crankshaft 29 and appropriate inlet/outlet valving for each cylinder block 23, 24 is achieved through timing belts around pulleys, etc.

The construction depicted in Figure 3 is essentially a dual in-line arrangement of piston blocks 23, 24. Clearly, several piston blocks 23, 24 can be arranged in line, that is to say extending into the plane of the figure such that respective rows of piston blocks 23, 24 are substantially parallel. Alternatively, piston blocks 23, 24 could be arranged in a staggered configuration as seen from a plan view with respective piston blocks 23, 24 being zig-zagged in the longitudinal direction of the crankshaft 29. In any event, it will be appreciated, as in

accordance with the object of the present invention that variable engine 21 construction can be achieved in order to assess engine performance, economy and exhaust emission levels. As also indicated previously, various combinations of piston blocks 23, 24, along with head member 25, 26 can be tried in order to 5 provide the best engine 21 performance or a compromise. Clearly, it is easier to alter a single modular component in order to evaluate empirically as described above, the engine 21 to achieve desired performance.

It is known to provide engine geometries which have a V configuration. Thus, as illustrated in Figure 4, the dual in-line construction of engine 21 shown in 10 Figure 3 can be altered to a V through inclination of respective piston blocks 23, 24 and associated head members 25, 26 at an angle to the crank case 22. In such circumstances, the crankshaft 29 is still held in timed cooperation with the control mechanism held within respective head members 25, 26 for each piston 27, 28 displacement through a timing belt as described previously. Each piston 27, 28 is 15 coupled in accordance with conventional practice to the crankshaft 29 in order to rotate that crankshaft 29 by displacement of a piston 27, 28 as a result of combustion. As with previous geometries, it will be appreciated that the engine 21 in the configuration depicted in Figure 4 can be tried empirically to determine engine 21 performance, economy and level of emissions. Furthermore, the 20 modular components of the engine 21 and in particular the cylinder blocks 23, 24 and the head members including the control mechanism for each piston/cylinder combustion chamber along with inlet/outlet valving can be varied in order to achieve the desired level of engine 21 operation.

A particular advantage of the present invention is that the engine 1; 21 may 25 be initially operated with a single piston/cylinder combustion mechanism in order to determine performance and then subsequent equivalent piston/cylinder assemblies added to the base crank case 2 in order to determine the multiplicity

effect of several such assemblies in one engine 1; 21. It will be appreciated that several combustion assemblies, ie. piston/cylinders in a multi-cylinder engine interact and effect each other's performance. For example, exhaust gases in a common manifold may be drawn into a cylinder during an induction stroke,  
5 adjacent cylinders recreate vibration effects and clearly there will be differential in heat distribution between central piston/cylinders and end piston/cylinder arrangements. Thus, in accordance with the present invention, the engine 1; 21 may be "built" from an initial single cylinder engine by adding further piston/cylinder assemblies appropriately and mutually adapted to achieve the  
10 desired levels of performance and economy and exhaust gas emissions. Previously, the interactive effects of multiple cylinder engines had to be guessed until an appropriate prototype was assembled for empirical testing.

As indicated above, the whole concept of the present invention is to allow flexibility in accordance with a modular construction. Thus, the crankshaft 8; 29 used in each respective engine 1; 21 can be adjusted to suit the number of pistons currently held within that engine 1; 21. However, the crank case 2; 22 will clearly normally include respective end wall bearings to support the crankshaft 8; 29. These bearings will typically be in the end walls of the crank case 2; 22 and also be provided by bearing panels located within the crank case 2; 22 itself. These bearing panels may be moveable within the crank case 2; 22 in order to coincide with piston block assemblies secured to the crank case 2; 22. The crankshaft 8; 29 will be of a conventional form with throw bearings about a central shaft axis to which the pistons 5; 27, 28 are secured. The crankshaft 8; 29 will also include a flywheel in order to maintain inertia as the various piston displacements rotate the crankshaft. This flywheel itself may be variable in order to accommodate 25 different engine geometries.

As indicated above, normally the crankshaft 8; 29 will be integrated with the reciprocal timing mechanism of an engine 1; 21. Thus, rotation of the crankshaft 8; 29 will result in reciprocal rotation of a pulley timing mechanism secured to the control mechanisms for each piston in order to achieve ignition of fuel for 5 combustion within each combustion chamber defined between the top of a respective piston 5; 27, 28 and the head members 4; 25, 26. Furthermore, it will be understood that appropriate encoders such as teeth or other features could be added to the crankshaft or flywheel in order to allow electronic control in accordance with known regimes to be implemented.

10 As intimated previously, in order to accommodate various configurations of crankshaft 8; 29, typically bearing panels will be located within the crank case 2; 22. These bearings panels will be moveable in order to be located between respective bearing throws of the crankshaft 8; 29. The bearing panels may be moved upon and captured by respective slides or slots in the crank case 2; 22 wall.

15 Clearly, as indicated previously, it is preferable if each modular element of the engine 1; 21 is substantially independently lubricated. Thus, each part of the engine 1; 21 will include a lubrication oil feed aperture and a drain aperture. However, it may also be desirable to provide a degree of lubrication between respective modular elements of the engine 1; 21, thus banjo-type bolts may be 20 inserted within the drain apertures and these banjo bolts coupled together with suitable piping typically of a flexible nature such that lubricating oil can be passed between modular components and through the crank case 2; 22, etc.

Each cylinder block 3; 23, 24 can be, as illustrated in the Figures, of a single cylinder type or incorporate two or more cylinders. Typically, these piston/cylinder 25 blocks 3; 23, 24 will be conventionally formed. However, for increased flexibilities, the cylinders within the blocks 3; 23, 24 may include cylinder linings which are

interchangeable to provide different performance, etc. Thus, the cylinder/piston blocks 3; 23, 24 will be cast and then machined dimensionally and/or a cylinder liner incorporated in order to provide an appropriate cylinder within the cylinder block 2; 22.

- 5       The head member 3; 25, 26 incorporates the control mechanism for ignition and exhaust of gases from the combustion chamber defined between the cylinders 5; 27, 28 and the head member 3; 25, 26. Typically, these control mechanisms include valves with tappets to open and close inlet/outlet apertures in the cylinders of each block 2; 23, 24 along with fuel injection mechanisms and spark plugs for  
10      fuel combustion ignition.

- Clearly, the engine 1; 21 must be cooled in accordance with conventional practice. Thus, at least the piston blocks 2; 23, 24 incorporate appropriate coolant pathways through which coolant can be supplied via an external pump in order to maintain engine 1; 21 temperature. Similarly, although each modular component 15 of the engine 1; 21 will typically be substantially independently lubricated to allow easier variation in engine 1; 21 construction, it will also be understood that lubricating oil may be supplied and circulated through lubrication piping as indicated previously. Within each modular component of the engine 1; 21 there will be appropriate splash and throw lubrication in order to achieve an acceptable  
20      level of lubrication within that respective module of the engine 1; 21.

- In order to ensure that the various modules of an engine 1; 21 are assembled correctly, it will be appreciated that register structures could be incorporated within respective modules in order to guarantee correct assembly. Furthermore, clearly some module combinations will be unacceptable and thus through  
25      appropriate choice of register structures assembly of these modules together will be prevented.

As with any modular construction, it will be appreciated that appropriate blanking plates will be necessary to cover portions of the engine 1; 21 to which piston blocks 3; 23, 24 are not secured or as in Figure 4, wherein the engine 1; 21 may be arranged with open areas. Thus, these blanking plates will be located over

5 the crank case 2; 22 or between the crank case 2; 22 and the bottom edges of the respective piston blocks 23, 24 (Figure 4) in order to provide a closed environment for the engine 1; 21. These blanking plates may be solid or flexible such that they are adjustable with varying engine 1; 21 construction. Thus, again with regard to the configuration depicted in Figure 4, it will be appreciated that the angle of

10 presentation of the respective piston block 23, 24 to the crank case 22 can be varied. Thus, a blanking plate 30 may be of a flexible or expandable form to accommodate such varying construction between the modular components 22, 23, 24 of the engine 21.

In order to allow various engine geometries, it will be appreciated that, in

15 essence the coupling between the crank case 2; 22 and the respective piston block 3; 23, 24 is of a variable configuration. Thus, this coupling may take the form whereby these piston blocks 3; 23, 24 may be slid in slots or hinged about edges between the blocks 3; 23, 24 and the crank case 2; 22. The purpose of these couplings between the blocks 3; 23, 24 and the crank case 2; 22 is to allow varying

20 configuration therebetween and thereby achieve differing geometries for the engine 1; 21. Clearly, as part of these varying configuration couplings between the parts of the engine 1; 21 are included timing mechanisms to couple rotation of the crankshaft 8; 29 with the control mechanisms to initiate piston displacement as a result of combustion. In such circumstances, it will be appreciated that inherent

25 adaptability and redundancy within the configuration means between the respective modular components of the engine 1; 21 must be incorporated. Thus, the timing belt coupling rotation of the crankshaft 8; 29 with the control

mechanisms in the head members 4; 25, 26 will typically be of differing configuration and so a tensioner pulley will be incorporated in order to allow for variation in the timing belt/chain length whilst retaining operational functionality.

Similarly, the couplings between the blocks 3; 23, 24 and the crank case 2; 22,

5 although allowing reconfiguration therebetween should also achieve sufficient robust retention of the varying geometries to ensure engine 1; 21 operation is not compromised. It will be appreciated, that there is inherent vibration of an internal combustion engine and thus couplings between the respective modular components of the engines 1; 21 must be able to resist dislocation as a result of such vibration

10 and other operational factors.

Clearly, the embodiments of the present invention depicted in the Figures are of a symbolic and pictorial nature and so with regard to a practical and operational engine 1; 21, it will be appreciated that various additional support and operational components must be added. For example, as illustrated typically the engine 1 will require some form of fuel carburation or injection along with inlet and outlet manifolds in order to provide a functional engine. It is submitted that a person skilled in the art would readily appreciate how such supplemental components may be added as further modules to the engines 1; 21 depicted in the Figures. In any event, it is part of the present invention to provide an engine 1; 21 which allows such a person skilled in the art to adapt and amend, particularly empirically, engine designs to achieve desired performance, economy and acceptable levels of emissions gas.

CLAIMS

1. An engine comprising a crank case to accommodate a crankshaft therethrough, at least one piston block secured to the crank case and with a piston therein coupled to the crankshaft and each piston block being secured to a head member in order to define a combustion chamber therebetween in which fuel combustion presents workload through displacement of the piston to the crankshaft in order to rotate that crankshaft and rotation of that crankshaft through a reciprocal timing coupling to combustion control means in each head member coordinates combustion within each piston block and therefore piston displacement for cooperative rotation therebetween of the crankshaft, the engine characterised in that the number of and/or relative angle of presentation between each piston block and the crank case is variable through alteration of configuration means located between each piston block and the crank case whilst maintaining respective piston displacement for cooperative rotation therebetween of the crankshaft.
2. An engine as claimed in Claim 1, wherein the configuration means includes hinges and slide slots between each said piston block and said crank case edge.
3. An engine as claimed in Claim 1 or Claim 2, wherein the crankshaft incorporates a flywheel in order to maintain inertia as the crankshaft is consecutively rotated by displacement of each piston as a result of combustion within its respective combustion chamber.
4. An engine as claimed in Claim 3, wherein the flywheel may be varied in response to the number of and/or relative angle of presentation between each piston block and the crank case through alteration of the configuration means.

5. An engine as claimed in any preceding claim, wherein the engine includes blanking plates secured within the engine in order to maintain the engine integrity despite specific engine construction as a result of less than a full compliment of piston blocks secured to the crank case and/or as a result of piston block angular presentation to the crank case.
6. An engine as claimed in any preceding claim, wherein the crank case is arranged in compartments and these compartments are consistent with a respective piston block to be secured to the crank case.
7. An engine as claimed in any preceding claim, wherein the crank case includes bearing panels to support the crankshaft.
8. An engine as claimed in Claim 7, wherein the bearing panels are moveable within the crank case in accordance with the specific crankshaft accommodated therethrough.
9. An engine as claimed in any preceding claim, wherein each piston block and its respective head member along with the crank case are substantially independently lubricated to facilitate modular assembly of the engine.
10. An engine as claimed in any preceding claim, wherein each piston block and its respective head member along with the crank case are coupled together by appropriate lubrication piping therebetween.
11. An engine substantially as hereinbefore described with reference to Figures 1 and 2.
12. An engine substantially as hereinbefore described with reference to Figures 3 and 4.